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DEVELOPMENT OF RUBBER-PLASTIC COMPOSITES FOR SONAR DOMES.(U)

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U.S. NAVAL APPLIED SCIENCE LABORATORY
NAVAL BASE
BROOKLYN 1, NEW YORK

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(6) DEVELOPMENT OF RUBBER-PLASTIC COMPOSITES FOR SONAR DOMES,

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Lab. Project 9300-7
Technical Memorandum #1

ABSTRACT

The U. S. Naval Applied Science Laboratory is developing and exploring rubber enclosed, heat and pressure cured and bonded laminated rubber-plastic composites as possible structural materials for various structural applications such as hull-mounted sonar dome windows, windows of VDS fish bodies, and sonar baffles. Physical properties studied to date have indicated, as expected that the structural properties of the composites are largely determined by the structural properties of the rigid plied-up plastic components. Preliminary acoustic measurements have indicated some good acoustic properties. Studies of the structural and acoustical properties of the rubber-plastic composites are continuing in order to eventually establish the feasibility of these materials for use in sonar dome applications.

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Technical Memorandum #1

ADMINISTRATIVE INFORMATION

Ref: (a) BUSHIPS ltr 10320 Ser 634C1-319 and its enclosure (1) of 17 Apr 1964
(b) Visit of Messrs. S. Gross and J. Natwick, Code 933, USNUSL to Mr. C. K. Chatten, Code 9360, NAVAPLSCIENLAB of 4 Mar 1963
(c) Military Standard, MIL-P-18177C, of 25 May 1960
(d) Proposed Federal Test Method Standard, No. 406, Plastics dated Jun 1960

Encl: (1) Figure 1 - Detail of Rubber-Plastic Composite Construction
(2) Table 1 - Recipes of Elastomers and Method of Fabrication of Composites
(3) Table 2 - Methods Used to Determine Structural Properties of Rubber-Plastic Composites
(4) Figure 2 - Laboratory Modified Bearing Strength Jig
(5) Table 3 - Physical Properties of Rubber-Plastic Composites and Components

BACKGROUND

1. The U. S. Naval Applied Science Laboratory has demonstrated the feasibility of integrally molding and bonding together layers of rubber and rigid plastics, having an all-rubber envelope, and is currently developing and exploring these heterogeneous rubber-plastic composites as potential structural materials for applications such as sonar dome windows and windows of towed sonar bodies. The development started with the concept that the combination of the plastic with the rubber in the composites would be expected to combine the structural rigidity of the plastic with the inherent water, corrosion and cavitation erosion resistance, and self-noise-attenuating characteristics of the rubber, to provide structurally sound sonar window materials. It was conceived also that these composites might be designed with sufficient structural strength to permit sonar dome construction without the type of truss work presently in steel sonar domes and the larger plastic domes, which interfere with sonar reception, reference (a).

2. After determining through liaison with Bureau of Ships, U.S.N. Underwater Sound Laboratory, David Taylor Model Basin and U.S.N. Underwater Sound Reference Laboratory, the service needs for a structural material having the unusual combinations of properties which might be expected of rubber-enclosed, laminated rubber-plastic composites, the NAVAPLSCIENLAB prepared a styrene butadiene rubber compound, NASL-C663 (formerly designated as ML-C663) rubber-epoxy glass composite and submitted this material to USNUSL for acoustic characterization. Pulse tube measurements of this material by USNUSL indicated promising acoustical properties. This led to interest by the BUSHIPS and USNUSL in reference (b), in the composites

as materials having potential for use as structural materials for sonar domes and windows or baffles of towed VDS bodies.

OBJECTIVE

3. The objective of this work is to explore the potential for, and develop rubber-plastic composites for various structural applications, including sonar dome materials.

DEVELOPMENT OF COMPOSITES

4. The composites being explored in the present study consist of n layers of a rigid plastic component and n + 1 layers of an elastomeric component. The components in the laminate are heat and pressure cured and bonded into a coherent, rubber enclosed material having rigidity in the mass and viscoelastic behavior in the surfaces. A typical rubber-plastic composite, in which n = 2, is shown schematically in Figure 1.

5. The composites which were prepared for the current study of structural characteristics, consisted of two plies of an epoxy glass and either of the two Laboratory developed compounds, SBR compound NASL-C663 and butyl rubber compound NASL-H677 (formerly designated as ASL-677). The SBR compound was chosen for its previously demonstrated cavitation erosion resistance in the Laboratory. The butyl rubber compound was chosen for its desirable acoustic transmissibility characteristics as shown by measurements at USNUSRL, and for its inherent low water permeability. The compositions of the two elastomer compounds used in the composites are given in Table 1. The rigid components of both the SBR-plastic and butyl rubber-plastic composites were identical, commercially available glass reinforced, precured epoxy resin sheets, 1/32 inch thick, type GEE of reference (c).

6. Fabrication techniques were similar for both types of composites, differing in the adhesives and curing schedules used. The procedure for fabrication of the respective composites was that described in Table 1, and resulted in composites such as that shown in Figure 1. It was necessary to lay the two plies of epoxy glass, with the lengthwise directions of the glass parallel to one another in both composites to avoid warpage.

CHARACTERIZATION OF THE COMPOSITES

7. The potential for the rubber-plastic composites for use in sonar domes depends on their structural properties - tensile, compressive, shear, flexural, and impact strengths; their acoustical properties - transmissibility, damping, and reflectivity characteristics; and their physical characteristics related to the

longevity and integrity of the composites in prolonged sea immersion - volume swell, bond strength between plies, chemical changes, and changes in viscoelastic behavior of the elastomeric components as a function of time of exposure. In view of the much greater strength characteristics of reinforced plastics over that of rubbers, it was clear that the structural properties of the composites would be closely related to the structural properties of the rigid component. Accordingly, it was decided to determine the structural properties of the composites by treating the materials as rigid plastics and using the testing methods outlined in reference (d) with appropriate modifications. The methods used in determining the structural characteristics of the SBR and butyl rubber-epoxy glass composites, together with the modifications in methods, are given in Table 2.

8. In determining bearing strength, a Laboratory modified jig was constructed, to accommodate the composites. This bearing strength jig, shown in Figure 2, utilizes a yoke which bears on the glass component of the composite. The jig differs from the specified jig in the manner of detection of deflection under load. The accuracy of this method of recording deflection is based on the assumption that the composite is a coherent structure and that measuring the deflection of part of the material is the same as measuring the deflection of the whole.

9. The physical characteristics of the composites determined to date are given in Table 3, together with the physical characteristics of the epoxy glass sheets and the elastomers. The strength properties of the epoxy glass and of the elastomers may be compared with those of the composites, but the strength properties of the two composites should not be compared with one another because of differences in thickness of the two sample materials.

10. The determination of acoustical properties of the composites has been initiated, but the results to date are useful only for qualitative comparisons. Pulse tube measurements conducted by USNUSL, reference (b), have shown that for a 3-ply epoxy-glass SBR NASL-C663 composite, the rho-c factor varies between 1.72×10^5 and 2.07×10^5 gr/cm^2 sec for frequencies between 18.8 and 14.14 kc. per second. This is compared to the rho-c factor of water which is approximately 1.5×10^5 gr/cm^2 sec. The attenuation factor was equal to -0.585 db/cm. During these measurements USNUSL found that water seepage took place through the cut edges of the composite which might account for the spread of rho-c values. The specimen edges will be sealed in new specimens which are being prepared for pulse tube measurements at USNUSL.

11. Noise reduction measured on a 5/16 inch thick, 2-glass, 3-rubber ply SBR, NASL-C663 composite, on the NAVAPLSCIENLAB Acoustic Facility for Transmission Loss Measurements (Screening Purposes Only) over a range of frequencies from 1,125 cps

to 10,250 cps, have indicated a gradually increasing level of noise reduction from approximately 1/2 db at the lowest frequency to about 5-1/2 db at the highest frequency. However, this information should be used for screening purposes only and not as an absolute value of noise reduction. The effects of the epoxy glass in the composite will be determined by subjecting an SBR, NASL-C663 all-rubber specimen to the same measurement.

CONCLUSIONS

12. An analysis of the data in Table 3 shows the following:

a. The tensile strengths and tensile modulii of both the SBR, NASL-C-663 rubber - and the NASL-H677 butyl rubber-epoxy glass composites are essentially the same as the tensile properties of the epoxy glass alone.

b. Flexural strengths and flexural modulii of the composites are indeterminant by the methods of measuring rigid plastics because standard beam formulas do not apply to beams which undergo the large deflections which the composites undergo during flexural loading. A need for more experimentation, varying span lengths, rubber thickness and specimen widths, to develop more applicable beam formulas, is indicated.

c. Bearing strengths of the SBR and butyl rubber-composites appear to be determined by the bearing strength of the epoxy glass, although the data indicates a lower bearing strength in the composite than that of the glass. These differences may be due to difficulties in accurately machining test specimens from the composite material. There is no reason to believe that the rubber should affect the bearing strength of the composite.

d. Compressive strengths and shear strengths of the composites are indeterminant by the methods of measuring rigid plastics because the composite material tends to fail by a combination of column buckling in compression and by flexure in shear. A revision of the specimen sizes and jig design will be undertaken to correct these deficiencies.

e. The impact strengths of both composites are at least as great as the impact strength of the epoxy glass alone.

f. In general, the structural properties of the rubber plastic composites appear to be largely determined by the structural characteristics of the epoxy-glass.

FUTURE WORK

13. The Laboratory is proceeding with the determination of structural, acoustical and physical characteristics of rubber-plastic composites. The data to date show that the structural properties of the composites are largely dependent on the structural properties of the rigid epoxy-glass components. Test methods will be modified to determine those structural properties, such as flexural strength, which could not be determined by the standard plastics test methods to establish indices of the expected structural behavior of rubber plastic composites with variations in number, spacing and direction of the plastic layers. The findings of research contractors to the BUSHIPS Sonar Dome Study Work Group will be utilized when they become available, to determine the structural design parameters necessary in rubber plastic composites for sonar domes.

14. Acoustical measurements of the rubber plastic composites will continue both in the Laboratory's Acoustic Facility for Transmission Loss Measurements (Screening Purposes Only) and in the pulse tube facility at USNUSL. Composites of epoxy-glass with SBR NASL-C663 and with butyl rubber NASL-H677, together with their all-rubber counterparts are being prepared and will be forwarded to USNUSL for pulse tube measurements. It is expected that structural and acoustic characterization of rubber-plastic composites will be completed by January 1965. Studies will continue to establish the feasibility of using rubber plastic composites as sonar dome and VDS fish window materials. Studies will be undertaken also to determine whether the structural rigidity of rubber plastic composites may be utilized in multi-rubber type composites in other sonar dome applications such as baffles.

FIGURE 1 - DETAIL OF RUBBER - PLASTIC COMPOSITE CONSTRUCTION

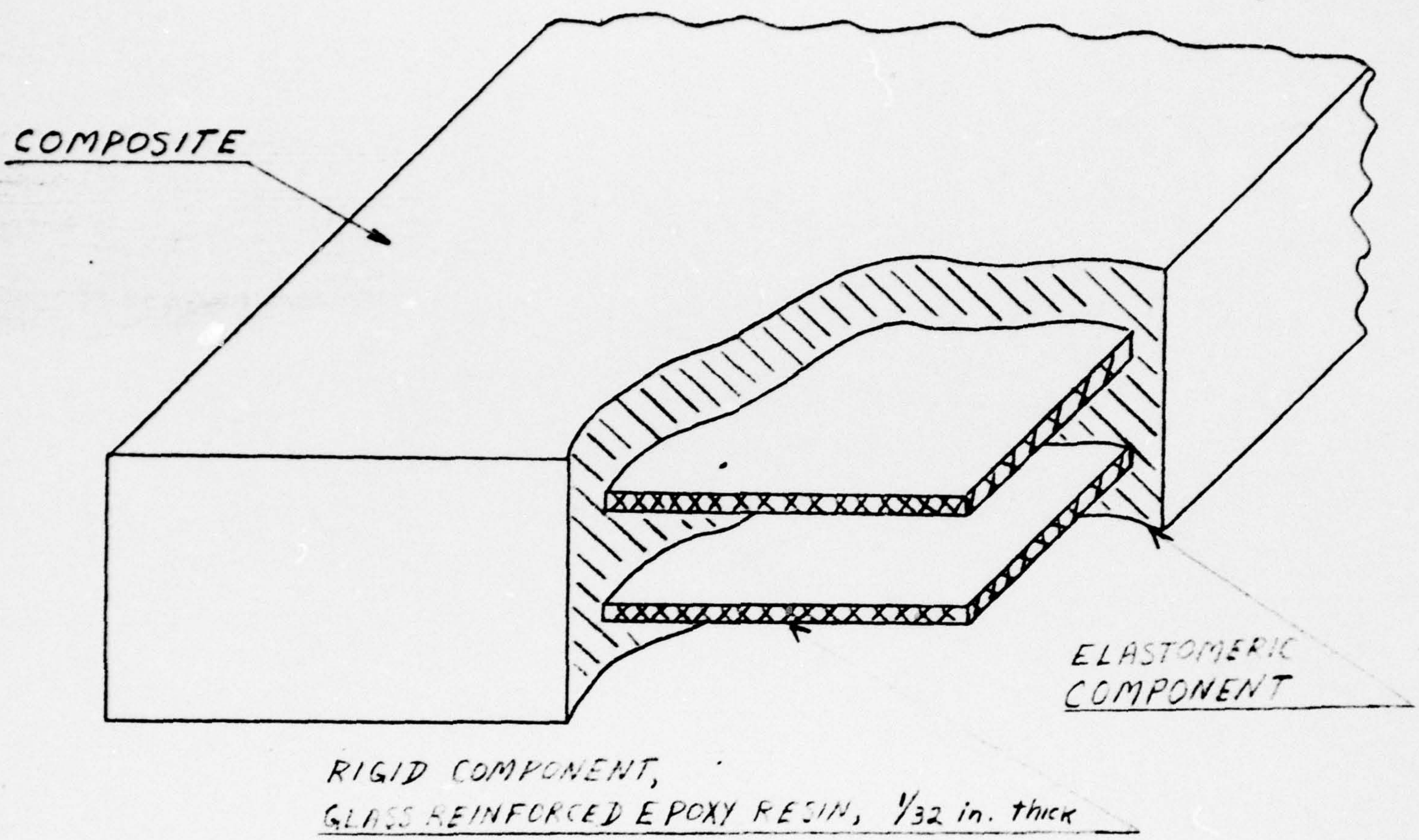

TABLE 1

RECIPES OF ELASTOMERS AND METHOD OF FABRICATION OF COMPOSITES

Ingredients	Concentration, phr — Compound No. NASL-C663 (1)	Concentration, phr — Compound No. NASL-H677 (2)
Butyl 035		100
SBR 1500	100	
Philblack E		30
Bondogen	2.0	
Hi Sil 233	54.5	
Stearic Acid	2.0	2.0
Zinc Oxide	5.0	5.0
Sulfur	2.0	1.25
Methyl Tuads		1.5
Agerite Stalite	1.0	
Altax	1.5	
Captax		1.0
Cumate	0.1	

	NASL-C663 (1)	NASL-H677 (2)
Mixing:	Band polymer on mill. Add ingredients in the order given. Cut, refine and sheet off.	
Calendering:	Calender mill stock to uniform smooth sheets 1/8 in. thick.	
Adhesive:	Chemlok 220 (Hughson Chemical Co.)	Ty Ply UP primer and Ty Ply BC adhesive (Marbon Chemical Div. of Borg Warner Corp.)
Application of Adhesive:	Brush apply adhesive on both surfaces of epoxy glass sheets and allow to dry.	Brush apply primer, dry, then brush apply adhesive on both surfaces of epoxy glass sheets and allow to dry.
Tackifying:	Brush benzene lightly over adhesion surfaces of calendered rubber sheets and allow to dry until tacky.	

Enclosure (1)

U. S. Naval Applied Science Laboratory

TABLE 1

	NASL-C663 (1)	NASL-H677 (2)
Assembling Composite:	Ply up 3 rubber and 2 epoxy glass sheets alternately to result in a composite having rubber outer layers and a rubber middle layer.	
Molding and Curing:	Place the assembled rubber plastic composite in a mold and cure in a steam heated press at 287°F for 1 hour.	Place the assembled rubber plastic composite in a mold and cure in a steam heated press at 320°F for 40 minutes.

Notes: (1) Formerly designated as ML-C633.
(2) Formerly designated as ASL-677.

TABLE 2

DETERMINE STRUCTURAL PROPERTIES OF RUBBER-PLASTIC COMPOSITES

Property Determined	Test Method Used, Method Number in Standards, ref (d)	Modification Made in Test Method To Account for Elastomeric Component in Composite
Tensile Strength	1011	None
Flexural Strength	1031	None used, but data indicates need for modification.
Bearing Strength	1051	A Laboratory modified bearing strength jig was used, Figure 2
Compressive Strength	1021	None used, but data indicates need for modification.
Shear Strength	1041	None used, but data indicates need for modification.
Impact Strength	1071	Toss factor approximated by using the entire specimen.

U. S. NAVAL APPLIED SCIENCE LABORATORY

LAB PROJECT 9300-7
TECHNICAL MEMORANDUM #1
ENCLOSURE (4)

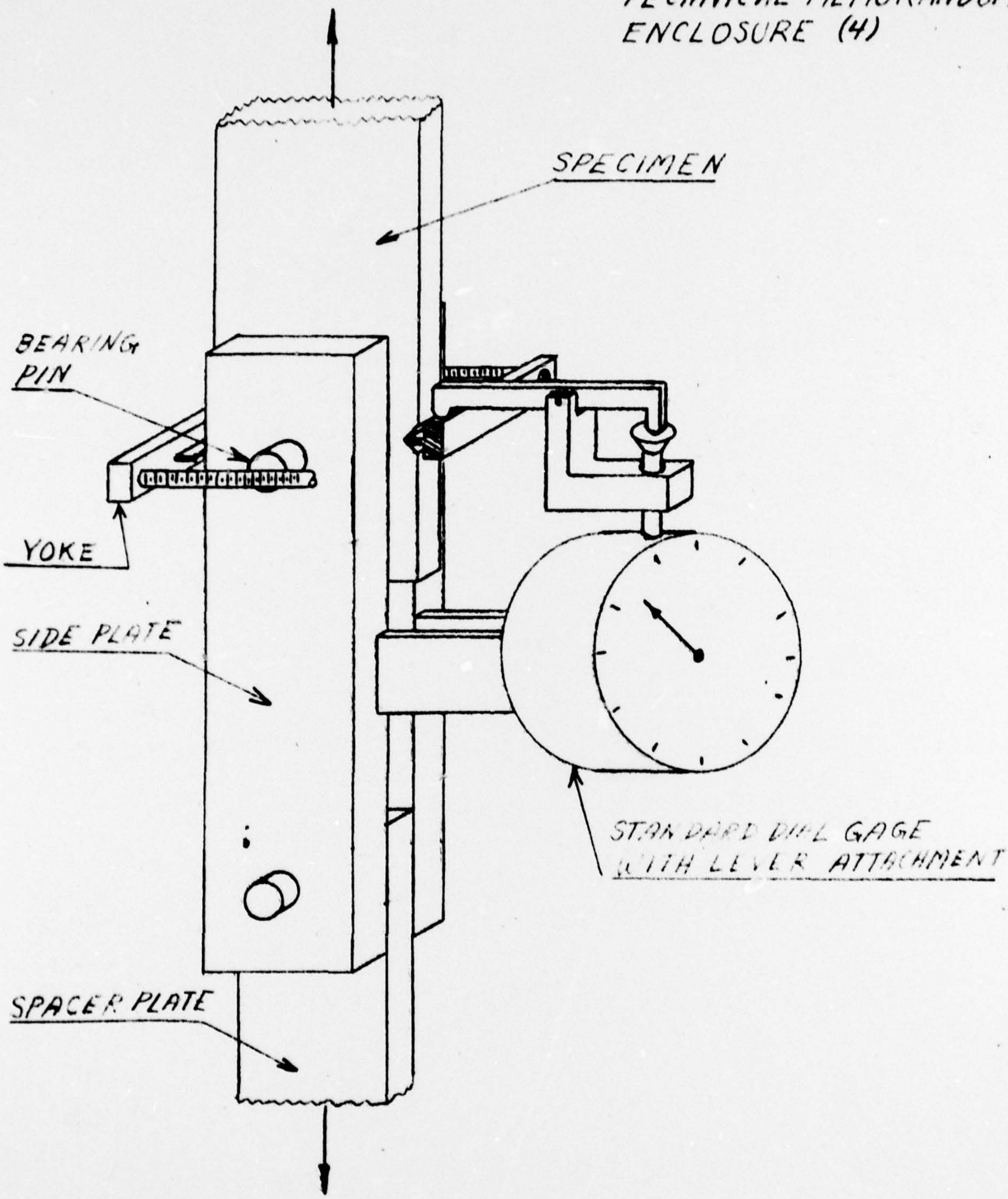

FIGURE 2 - LABORATORY MODIFIED BEARING STRENGTH JIG

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TABLE 3

PHYSICAL PROPERTIES OF RUBBER-PLASTIC COMPOSITES AND COMPON

Property	Epoxy Glass Sheets Cross wise	Epoxy Glass Sheets Length-wise	SBR Composite, Compound NASL-C663 With 2 Epoxy Glass Plies: Elasto-meric Com-ponent	Properties Based on Composite Area: Cross-wise	Properties Based on Composite Area: Length-wise	Properties Based on Area of Epoxy Glass in Composite: Cross-wise	Properties Based on Area of Epoxy Glass in Composite: Length-wise	Elasto meric Com-ponent
Tensile Strength psi	33,820	49,760	2,980	6,670	8,780	30,080	39,800	2,870
Tensile Modulus of Elasticity psi	2.96×10^6	3.66×10^6	-	0.82×10^6	1.08×10^6	3.62×10^6	4.78×10^6	-
Flexural Strengh psi	59,790	90,180	-	(1)	(1)	(1)	(1)	-
Flexural Modulus of Elasticity psi	3.07×10^6	3.64×10^6	-	(1)	(1)	(1)	(2)	-
Bearing Strength psi	28,830	32,660	-	4,250	5,510	18,870	24,150	-
Compressive Strength psi	31,860	36,760	-	(1)	(1)	(1)	(1)	-
Impact Strength ft-lb/in. width	15.93	25.82	-	4.79	5.62	22.0	25.6	-
Shear Strength psi	10,240	11,040	-	(1)	(1)	(1)	(1)	-
Hardness, Shore 'A' points	-	-	75	-	-	-	-	53
Ultimate Elongation, %	1.5	1.5	820	-	-	-	-	720
Modulus at 300% Elongation psi	-	-	480	-	-	-	-	430
Tear Strength lbs/in. width	-	-	266	-	-	-	-	75

Note: (1) Indeterminant.

TABLE 3

RTIES OF RUBBER-PLASTIC COMPOSITES AND COMPONENTS

Composite, Compound NASL-C663 With 2 Epoxy Glass Plies					Butyl Rubber Composite, Compound NASL-H677 With 2 Epoxy Glass Plies			
Properties Based n Composite Area		Properties Based on Area of Epoxy Glass in Composite		Elastomeric Component	Properties Based on Composite Area		Properties Based on Area of Epoxy Glass in Composite	
Cross-wise	Length-wise	Cross-wise	Length-wise		Cross-wise	Length-wise	Cross-wise	Length-wise
6,670	8,780	30,080	39,800	2,870	8,180	10,913	30,330	38,940
.82x10^{6}	1.08x10^{6}	3.62x10^{6}	4.78x10^{6}	-	0.60x10^{6}	0.70x10^{6}	2.2x10^{6}	2.6x10^{6}
(1)	(1)	(1)	(1)	-	(1)	(1)	(1)	(1)
(1)	(1)	(1)	(2)	-	(1)	(1)	(1)	(1)
4,250	5,510	18,870	24,150	-	5,510	6,160	19,500	21,810
(1)	(1)	(1)	(1)	-	(1)	(1)	(1)	(1)
4.79	5.62	22.0	25.6	-	5.96	6.5	21.6	23.8
(1)	(1)	(1)	(1)	-	(1)	(1)	(1)	(1)
-	-	-	-	53	-	-	-	-
-	-	-	-	720	-	-	-	-
-	-	-	-	430	-	-	-	-
-	-	-	-	75	-	-	-	-

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